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ERIE MINING COMPANY
TACONITE HARBOR POWER PLANT
BIOLOGICAL MONITORING PROGRAM

COOLING WATER INTAKE
JANUARY - DECEMBER 1976
NPDES PERMIT NO. MN 0002208

APRIL 15, 1977

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FINAL REPORT

BIOLOGICAL MONITORING PROGRAM

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NPDES PERMIT NO. MN 0002208

PREPARED BY

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APRIL 15, 1977

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ABSTRACT

Erie Mining Company owns and operates the Taconite Harbor Power Plant near Schroeder, Minnesota. Taconite Harbor Power Plant is a steam-electric generating station which draws cooling water from Lake Superior. During 1976, a biological monitoring program was conducted of the cooling water intake to assess the impact of cooling water usage on fishery resources of Lake Superior.

Sampling procedures in the monitoring program were designed to measure total annual impingement of adult and immature fish and to estimate the total annual entrainment of fish eggs and larvae. Measurement of total annual impingement involved the combination of two sampling methods. In the first method, fish captured in traveling screen discharge catch basket were identified, counted and measured. Traveling screen operation is required weekly to remove debris from the screen well in the intake structure. In the second method, floating dead fish were also removed weekly from the screen well with a dip net, and these fish were identified, counted and measured. Estimation of the total annual entrainment of fish eggs and larvae was based on weekly sampling of the cooling water intake with a plankton net. Each sample was 24 hours in duration and results were reported in numbers of fish eggs or fish larvae per 100 liters. The result was multiplied by the total cooling water flow for the sample week to provide weekly entrainment totals. Summation of the weekly entrainment totals equalled the total annual entrainment estimate.

Total annual fish impingement was measured at 10,172 fish. Smelt comprised 98.24% of the total and amounted to 9,993 individuals. Burbot was the only other species with noticeable impingement figures - 115 individuals representing

1.13% of the total. Ten other species were encountered and they comprised the remaining 0.63%. Smelt impingement losses were minimal and of no effect after comparison with the 1976 total smelt production of 2.6 million pounds. Impingement losses for the other species were minute and termed inconsequential.

Total annual entrainment estimates were 2,125,794 fish eggs and 6,447,558 fish larvae. Smelt eggs accounted for 88.5% of the fish egg estimate, and smelt larvae accounted for 97.8% of fish larvae estimate. Success percentages of fertilized egg to larvae to immature to adult stages are very low, so the entrainment losses probably represented less than 1,000 adult fish.

Smelt egg and larvae losses can also be converted to the loss of the fecundity of 261 adult females. In any light, the entrainment losses were small in comparison to impingement losses which have already been termed minute and inconsequential.

In conclusion, cooling water usage at the Taconite Harbor Power Plant has no measurable impact on the fishery resources of Lake Superior, and modification of the existing cooling water intake structure will not be necessary.

SECTION 1

COOLING WATER INTAKE STRUCTURE

A biological monitoring program was conducted during 1976 of the cooling water intake at the Erie Mining Company Taconite Harbor Power Plant. This one-year program was developed under guidance from the Minnesota Pollution Control Agency pursuant to requirements of Public Law 92-500, Section 316(b), and Minnesota Regulation WPC (u) (3).

1.1 GENERAL DESCRIPTION

Erie Mining Company is a commercial producer of iron ore pellets. Mines and process buildings are located at the plantsite near Hoyt Lakes, Minnesota. Pellet loading dock, coal dock and power plant to supply plantsite energy are located at Taconite Harbor on the north shore of Lake Superior. Taconite Harbor, approximately two miles southeast of Schroeder, Minnesota in Cook County, is in Lot 4 (SW-SW) of Section 1, Township 58N, Range 5W (Figure 1-1). Taconite Harbor was constructed in conjunction with the Hoyt Lakes plantsite and completed in 1957 (Figure 1-2). The Harbor which provides shelter and access to the docks includes man-made breakwaters and uniform water depths. The entire Harbor was enclosed during construction, and the water was pumped out to allow contouring of the bottom. Water depths are 30 feet near the docks, 22 feet over the cooling water intake pipes and approach 60 feet near Bear Island and its adjacent breakwaters. The bottom is basically rock and gravel on ledge with little aquatic plant life. Two Island River enters the Harbor south of the ore dock.

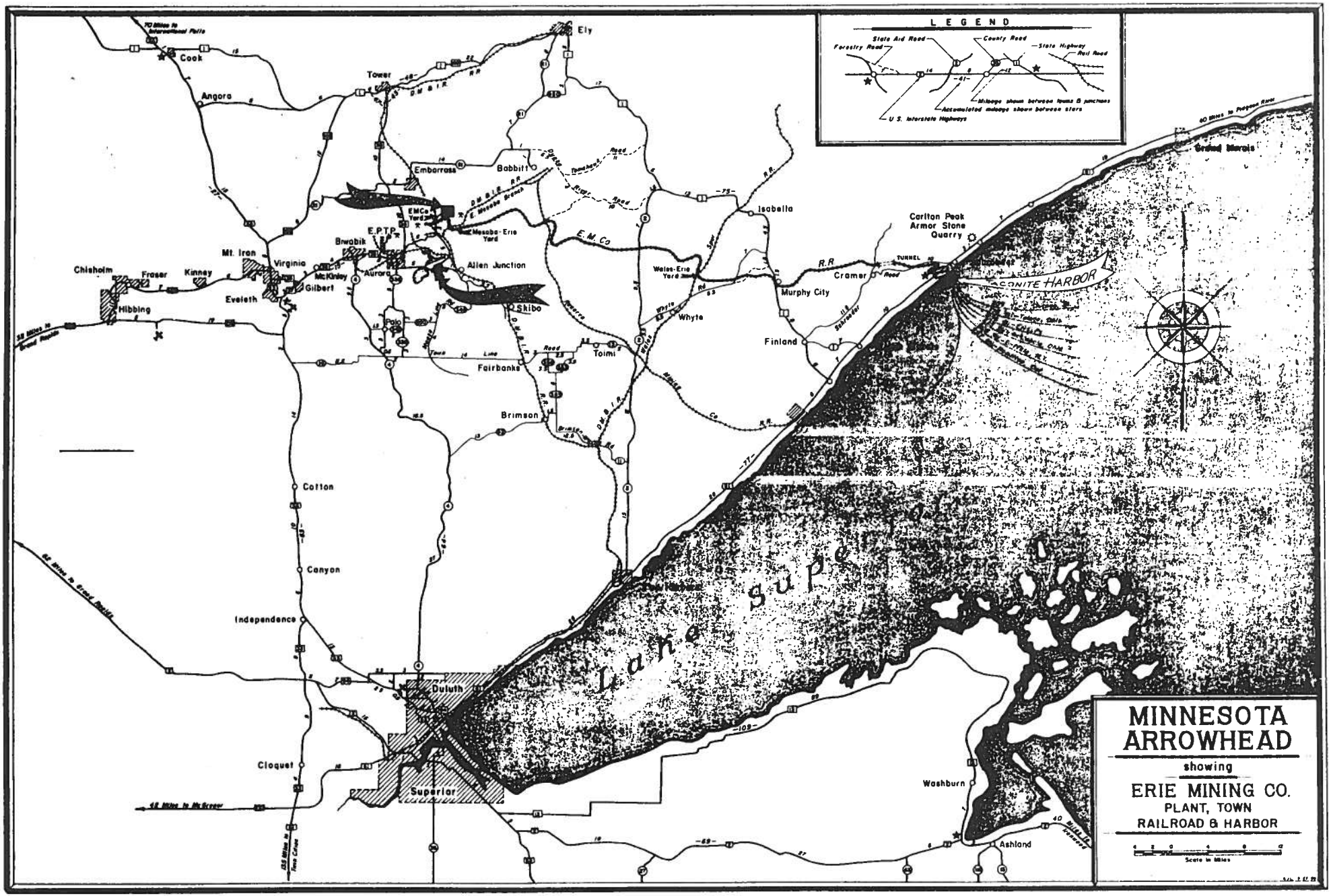

FIGURE 1-1. MAP OF MINNESOTA ARROWHEAD SHOWING LOCATION OF ERIE MINING COMPANY PLANT, RAILROAD AND HARBOR

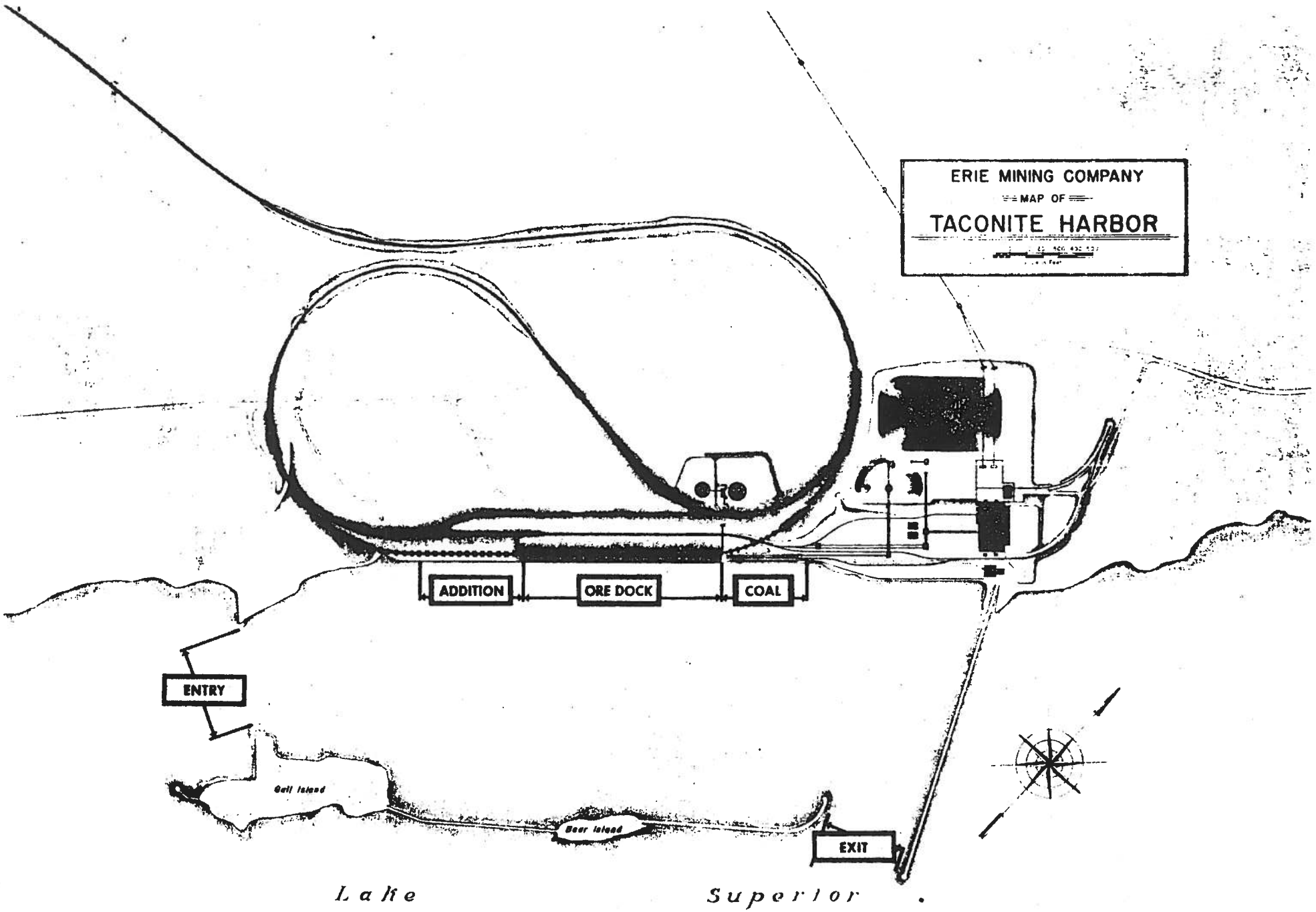

FIGURE 1-2. MAP OF TACONITE HARBOR

1.2 INTAKE DESCRIPTION

Power plant cooling water flows into the screen house through two, seven foot diameter intake pipes. The pipes extend approximately 295 feet from the screen house and lie along the Harbor bottom in 22 feet of water. Water flows into the screen well, passes through the coarse bar screen and vertical traveling screens, and enters the circulating water pumps. It is pumped to the condensors and flows out the discharge tunnel into Lake Superior on the east (lake) side of the east breakwater. Water supplied to the power plant by service water pumps flows out the same discharge. General arrangement of the intake structure and equipment is depicted in Figures 1-3, 1-4, and 1-5.

1.3 PLANT OPERATION

Taconite Harbor Power Plant is equipped with three, coal-fired, steam electric generating units. Each unit is rated at 75 megawatts (MW) providing for a total plant capacity of 225 MW. Power supplied to the Hoyt Lakes plantsite is normally 130-150 MW generated by two units. Plant output will exceed 150 MW for short periods when power is returned to Minnesota Power and Light Company for power borrowed at the Dunka Mine near Babbitt. Payback of power to MP&L requires operation of three units.

Cooling water is supplied to all three units by four circulating water pumps located in the screen house. Each circulating water pump is rated at 32,000 gallons per minute (gpm). Operation of four

ERIE MINING COMPANY - TACONITE HARBOR POWER PLANT
LOCATION PLAN

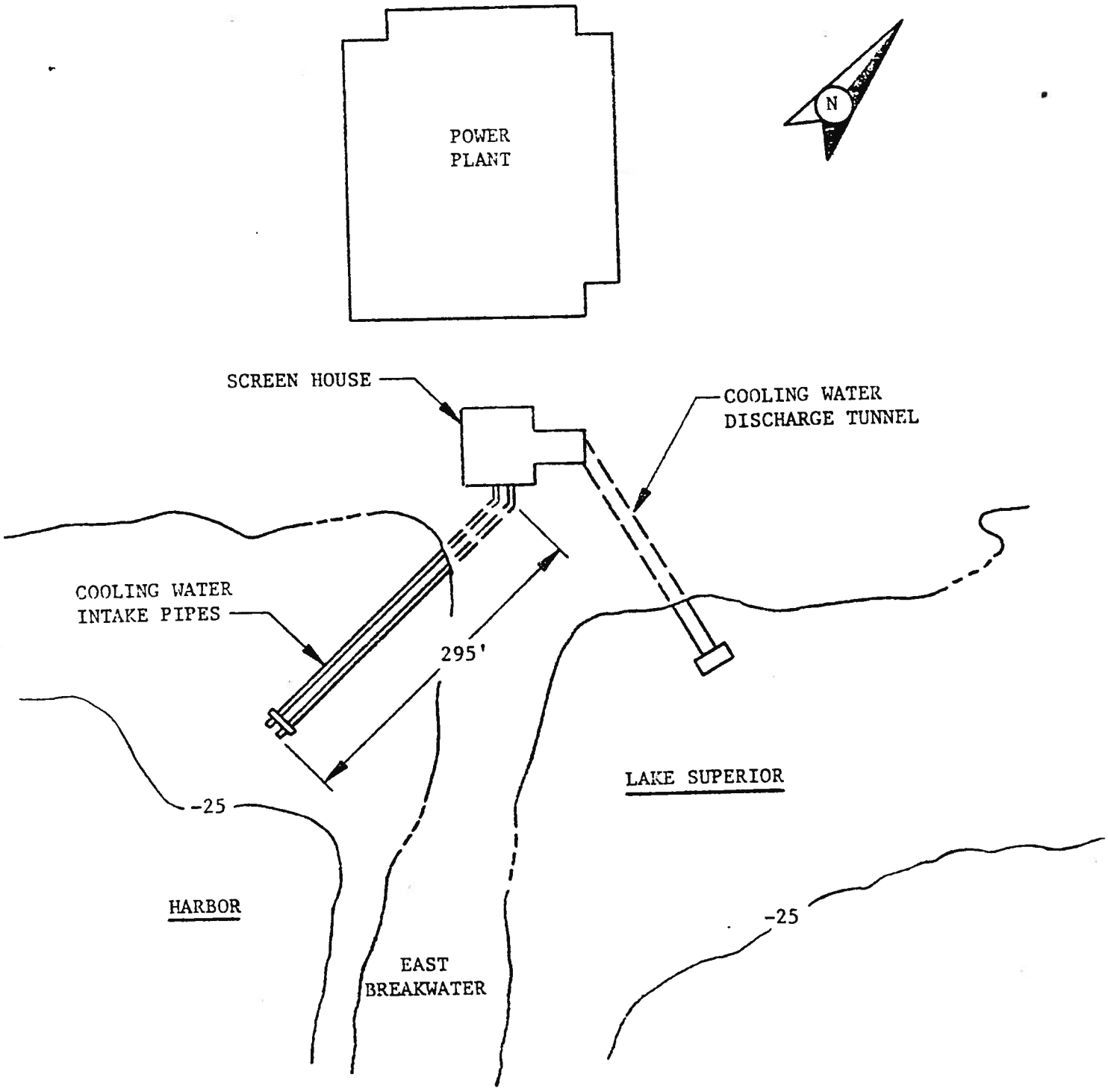

FIGURE 1-3

ERIE MINING COMPANY - TACONITE HARBOR POWER PLANT
COOLING WATER INTAKE SYSTEM

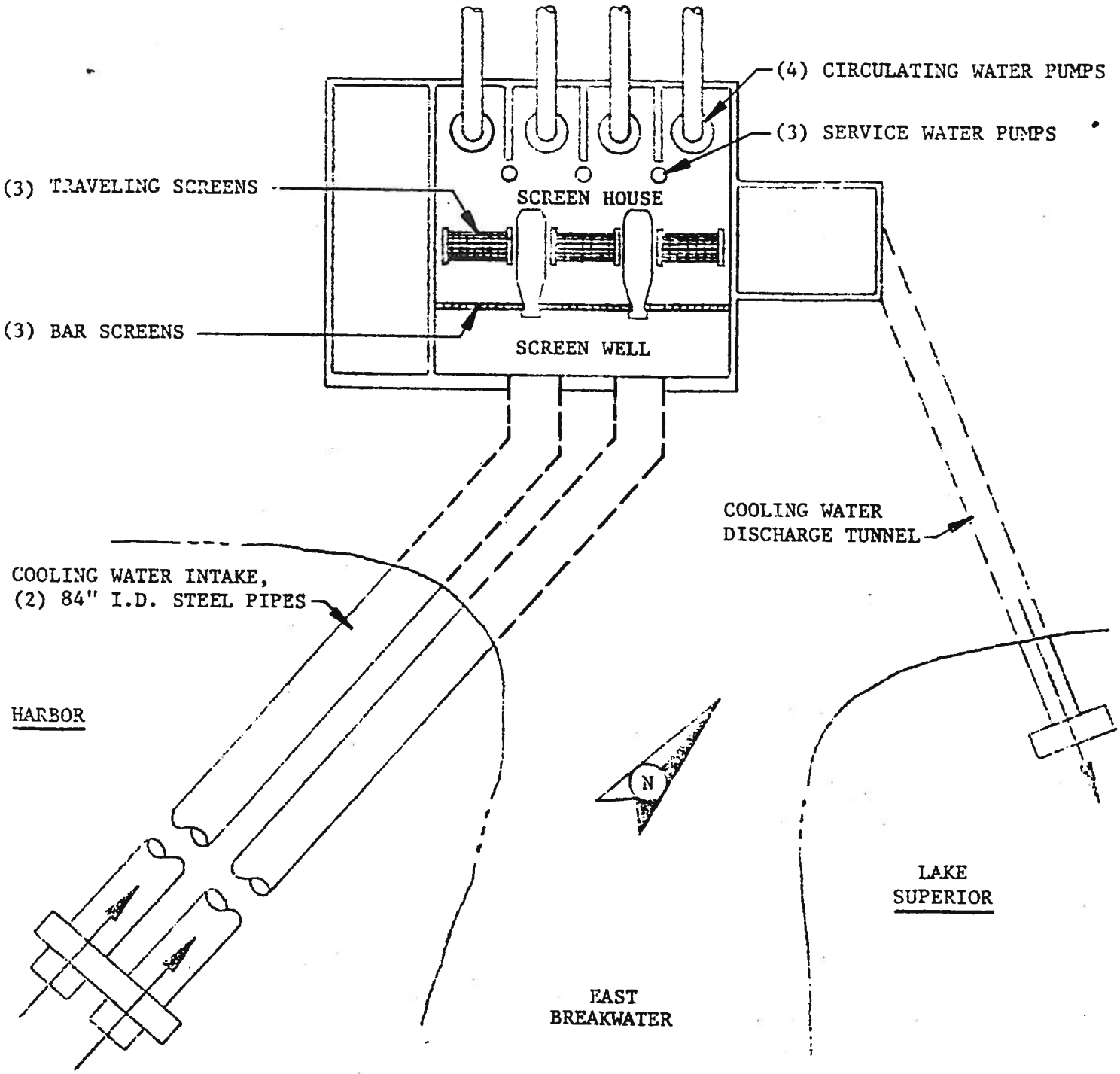

FIGURE 1-4

ERIE MINING COMPANY - TACONITE HARBOR POWER PLANT
SCREEN HOUSE ARRANGEMENT AND EQUIPMENT

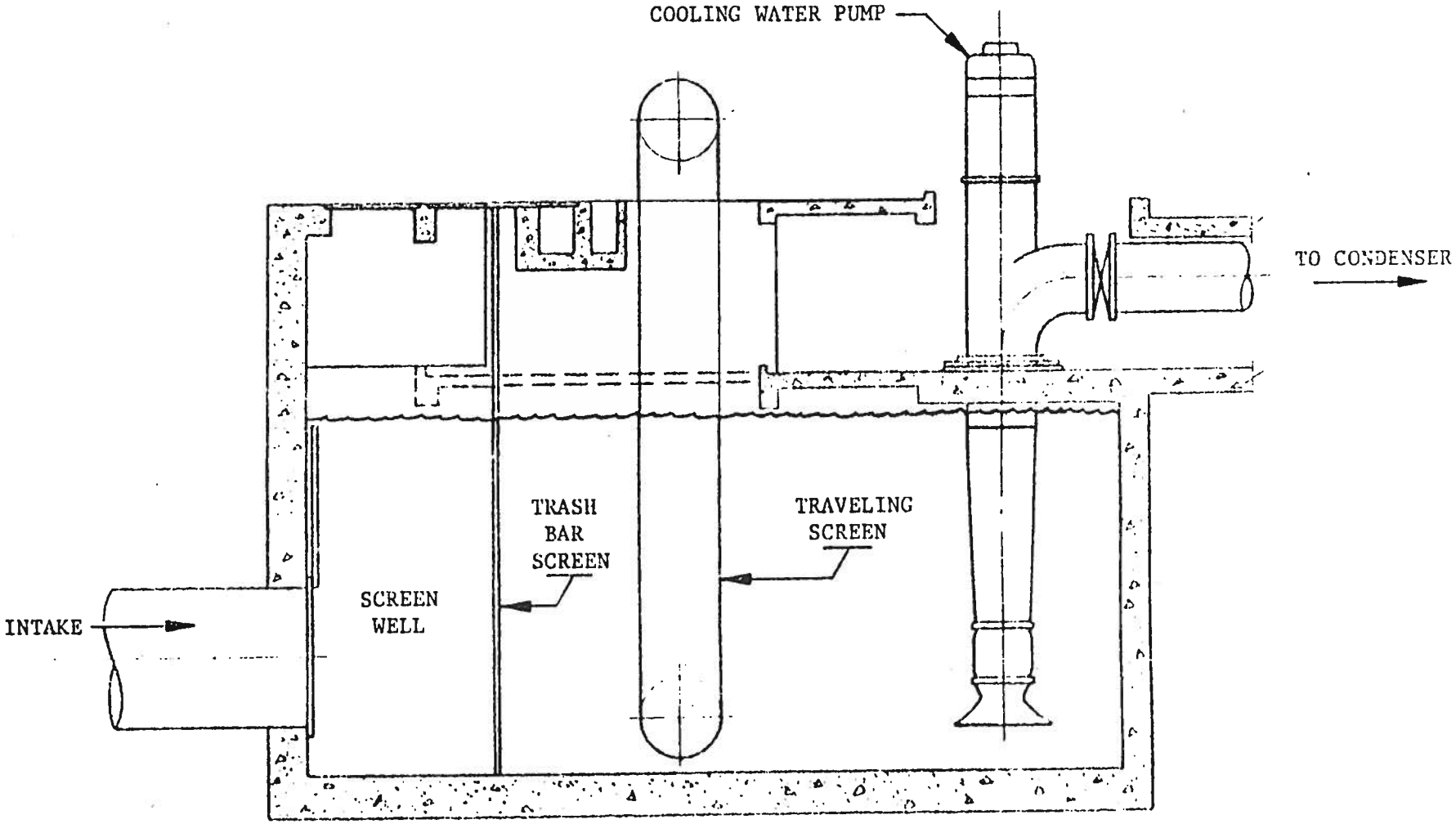

FIGURE 1-5

pumps is required periodically when the inlet cooling water temperature is too high for efficient condensor cooling, or when all three units are operating to provide the extra power for MP&L payback. Three circulating water pumps supply the necessary cooling water during months of colder inlet water and normal plant load. Figure 1-6 is a plot of average inlet and outlet cooling water temperatures with respect to each month during the monitoring program. Table 1-1 lists total cooling water usage, average inlet and outlet cooling water temperatures and plant capacity factor (power output in % of total plant capacity) with respect to each month during the monitoring program.

As daily cooling water usage varies from 141.0 to 187.0 million gallons per day, water velocities in the intake structure vary accordingly. At the intake pipes, velocities range from 2.83 to 3.78 feet per second, and at the traveling screens, velocities range from 0.40 to 0.54 feet per second. The difference between the minimum and maximum values represents the increased flow from operation of the fourth circulating pump and several service water pumps.

1.4 SCREEN SPECIFICATIONS AND OPERATIONS

The four circulating water pumps are serviced by three coarse bar screens and three traveling screens. The bar screens are 3-1/2 inch mesh and are seven feet forward of the traveling screens. Large debris deposited in front of the bar screens is removed as necessary. Each traveling screen is 10 feet wide and on 30 foot shaft centers, but the effective area of the screen is limited by the average water depth

ERIE MINING COMPANY-TACONITE HARBOR
1976 MONTHLY AVERAGE COOLING WATER TEMPERATURES

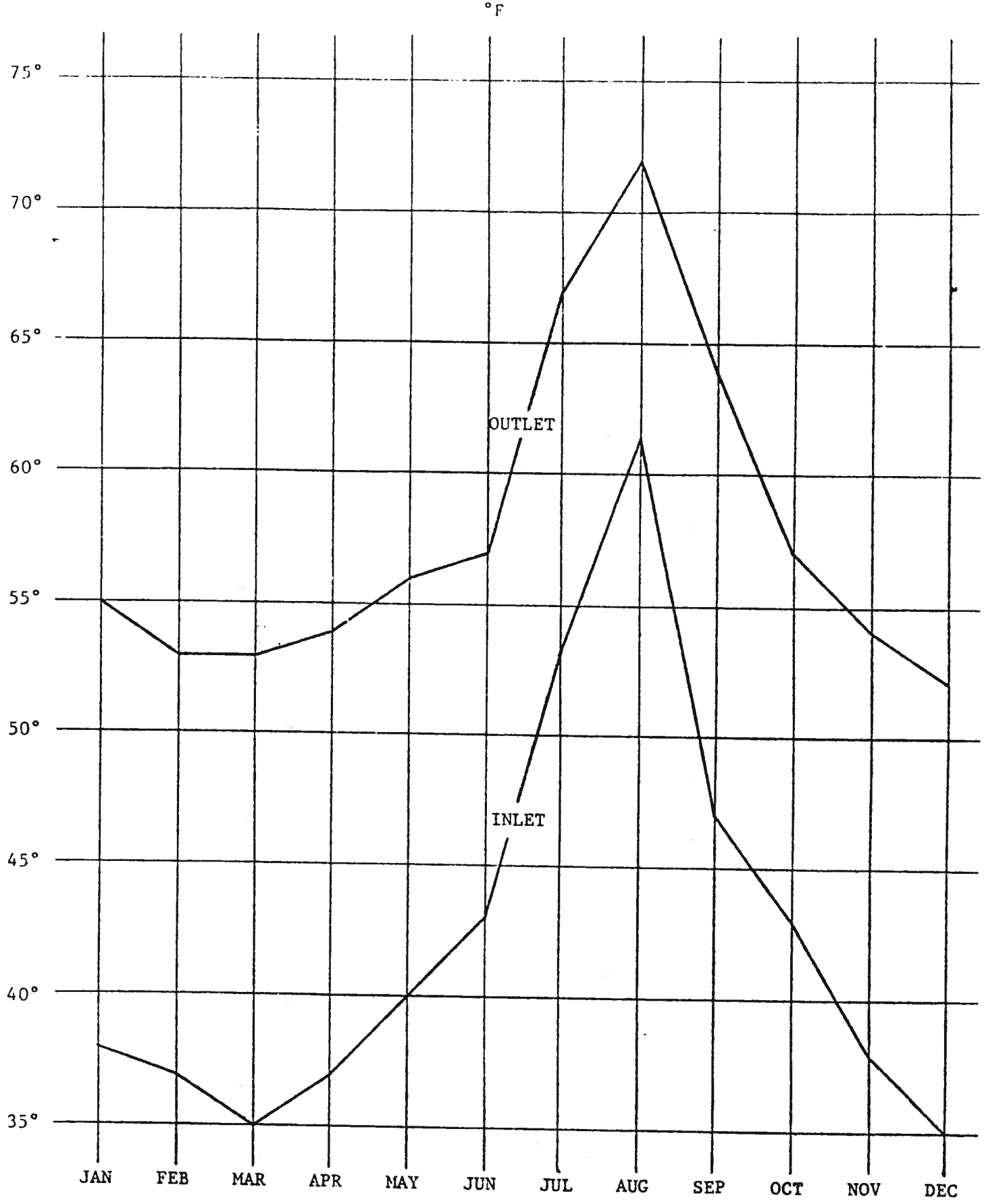

FIGURE 1-6

TABLE 1-1

MONTHLY COOLING WATER USAGE, INLET & OUTLET TEMPERATURES, AND PLANT CAPACITY FACTOR DURING ONE-YEAR MONITORING PROGRAM

MONTH	TOTAL COOLING WATER USAGE (GAL. x 10^9)	AVERAGE COOLING WATER TEMPERATURES, °F INLET	OUTLET	PLANT CAPACITY FACTOR, %
JANUARY	4.37	38	55	61.2
FEBRUARY	4.09	37	53	63.6
MARCH	4.37	35	53	68.9
APRIL	4.23	37	54	69.8
MAY	5.27	40	56	75.0
JUNE	5.16	43	57	65.0
JULY	4.95	53	67	64.6
AUGUST	5.80	61	72	66.9
SEPTEMBER	5.61	47	64	65.7
OCTOBER	5.80	43	59	67.3
NOVEMBER	5.17	38	54	63.5
DECEMBER	4.86	35	52	61.5

in the screen well of 18 feet. Screen operating speeds are 2.5 feet per minute (fpm) or 10.0 fpm, and the screen mesh is 3/8 inch. Screen wash water is supplied by a service water pump rated at 950 gpm and 87 psi.

Traveling screens are normally operated once per week for one hour. Screen speed is set at 2.5 fpm, and the screens are under continual wash. Screen operation frequency will vary from once per week according to the amount of debris present in the screen well. Daily screen operation is required during storms which bring large amounts of debris into the screen well. Likewise, operation can be less frequent when debris load in the screen well is negligible.

SECTION 2

SAMPLING DATA

2.1 ADULT AND IMMATURE FISH MONITORING

2.1.1 SAMPLING PROCEDURES AND EQUIPMENT

Three procedures were used for the monitoring of adult and immature fish impingement in the intake structure. Samples were collected of the adult and immature fish impinged on the traveling screens for each weekly operation of the screens during 1976. A 1/4 inch mesh screen was placed in the screen wash discharge trough to prevent fish from escaping. In addition, the trough discharged onto a concrete slab located approximately 25 feet from the Harbor shore. Fish in the discharge catch basket were identified, counted and measured.

Floating dead fish, adult and immature, not impinged on the traveling screens were removed periodically (usually weekly) from the screen well. Fish tended to collect in the corners of the screen well and were removed with a dip net. The fish were identified, counted and measured.

A 250 foot test gill net was placed in the Harbor waters (source water body) in the proximity of the intake pipes (Figure 2-1). The test gill net had five, 50 foot panels of 3/4", 1", 1-1/4", 1-1/2" and 2" mesh. Adult and immature fish collected were identified, counted, weighed and measured. Netting was done twice during periods of high impingement rates. All game fish were returned to the waters alive.

ERIE MINING COMPANY - TACONITE HARBOR POWER PLANT
GILL NET PLACEMENT

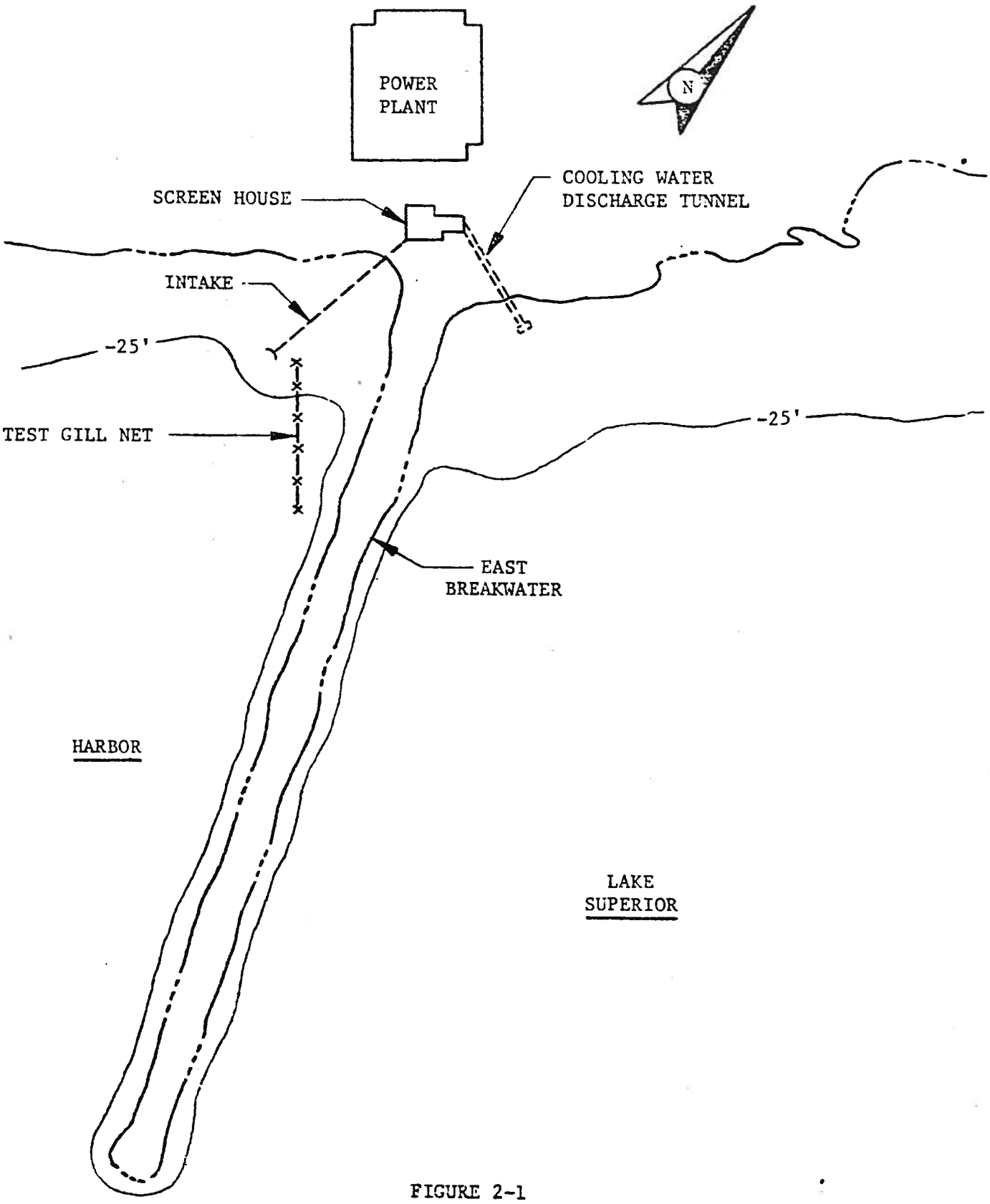

FIGURE 2-1

2.1.2 SAMPLING RESULTS

A total of 6,118 fish representing nine species were collected from the traveling screen discharge catch basket during the one-year monitoring program. Smelt, numbering 6,010, represented nearly the entire total. Table 2-1 summarizes the results of fish collection from the traveling screen discharge catch basket. Monthly statistics are in Table 2-2.

A total of 4,054 floating dead fish representing eight species were removed from the screen well during 1976. The smelt total of 3,983 approached the total number as in the traveling screen impingement results. A summary for the one-year monitoring program is presented in Table 2-3, and monthly statistics are in Table 2-4.

The two, 24 hour netting periods in the source water body produced 25 fish representing five species. Table 2-5 summarizes the netting results, and statistics for each netting effort are in Table 2-6.

TABLE 2-1

SUMMARY OF CATCH DATA FROM TRAVELING SCREENS DISCHARGE CATCH BASKET DURING ONE-YEAR MONITORING PROGRAM

SPECIES	NUMBER	AVERAGE LENGTH (IN.)	% TOTAL NUMBER
SMELT	6,010	5	98.2
BURBOT	60	16	1.0
CISCO	21	4	0.3
ALEWIFE	16	5	0.3
STICKLEBACK MINNOW	6	3	0.1
WALLEYE	2	12	0.03
LAKE TROUT	1	18	0.02
BLUE FIN HERRING	1	12	0.02
BULLHEAD	1	8	0.02
TOTAL NUMBER	6,118		

TABLE 2-2

MONTHLY SUMMARY OF NUMBER OF FISH FROM TRAVELING SCREENS
DISCHARGE CATCH BASKET DURING ONE-YEAR MONITORING PROGRAM

MONTH	SMELT	BURBOT	CISCO	ALEWIFE	STICKLEBACK MINNOW	WALLEYE	LAKE TROUT	BLUE FIN HERRING	BULLHEAD
JANUARY	1								
FEBRUARY									
MARCH	4								
APRIL	105				6				
MAY	1,327								
JUNE	4,427	5	20						
JULY	48	5	1	5					
AUGUST	25	20		4		1			
SEPTEMBER	60	14		6					
OCTOBER	7	5							
NOVEMBER	3	5				1			1
DECEMBER	3	6		1			1	1	
TOTALS	6,010	60	21	16	6	2	1	1	1

TABLE 2-3

SUMMARY OF FLOATING DEAD FISH REMOVED FROM THE SCREEN WELL DURING ONE-YEAR MONITORING PROGRAM

SPECIES	NUMBER	AVERAGE LENGTH (IN.)	% TOTAL NUMBER
SMELT	3,983	6	98.2
BURBOT	55	14	1.4
ALEWIFE	5	6	0.12
CISCO	4	4	0.10
NORTHERN PIKE	3	13	0.07
WHITEFISH	2	17	0.05
WALLEYE	1	12	0.03
LAMPREY	1	14	0.03
TOTAL NUMBER	4,054		

TABLE 2-5

SUMMARY OF NETTING RESULTS DURING
ONE-YEAR MONITORING PROGRAM

SPECIES	NUMBER	AVERAGE LENGTH (IN.)	% TOTAL NUMBER
WHITEFISH	10	15	40
SMELT	6	8	24
BURBOT	5	15	20
LAKE TROUT	2	10	8
NORTHERN PIKE	2	21	8
	25		

TABLE 2-6

RESULTS FOR EACH NETTING EFFORT

MAY 4-5, 1976

SPECIES	NUMBER	AVERAGE LENGTH (IN.)	AVERAGE WEIGHT (OZ.)
WHITEFISH	7	14	11
SMELT	6	8	2
LAKE TROUT	2	10	4
NORTHERN PIKE	2	21	34
BURBOT	2	16	14

JUNE 8-9, 1976

SPECIES	NUMBER	AVERAGE LENGTH (IN.)	AVERAGE WEIGHT (OZ.)
WHITEFISH	3	17	19
BURBOT	3	20	37

2.2 FISH EGG AND LARVAE MONITORING

2.2.1 SAMPLING PROCEDURES AND EQUIPMENT

Plankton net samples for fish eggs and larvae entrained in the cooling water were collected weekly during the one-year monitoring program. Sampling occurred in the cooling water intake structure, and not in the cooling water discharge tunnel. Suspension of a plankton net in the discharge was not possible due to the high velocity of the discharge water and general inaccessibility of the tunnel. Sampling was accomplished by placing a small, submersible pump in the intake cooling water after the water had passed the traveling screens. The pump provided the flow through a discharge hose into the plankton net which was suspended vertically in the screen well. Approximately 90% of the plankton net was immersed in the screen well to allow proper straining action. Equipment arrangement for sampling is shown in Figure 2-2.

The sample pump was set at a depth of two feet for samples collected from January 1, 1976 to May 10, 1976. At the request of the Minnesota Pollution Control Agency, sampling was done on May 17-18 and May 24-25, 1976, to determine the extent of eggs and larvae stratification at different depths within the screen well. Results from these samples showed no true stratification pattern, but the sample pump was lowered to an eight-foot depth where slightly higher egg and larvae counts were occasionally found. An eight-foot depth also provided for sampling near the midpoint of flow.

ERIE MINING COMPANY - TACONITE HARBOR POWER PLANT
PLANKTON NET SAMPLING ARRANGEMENT

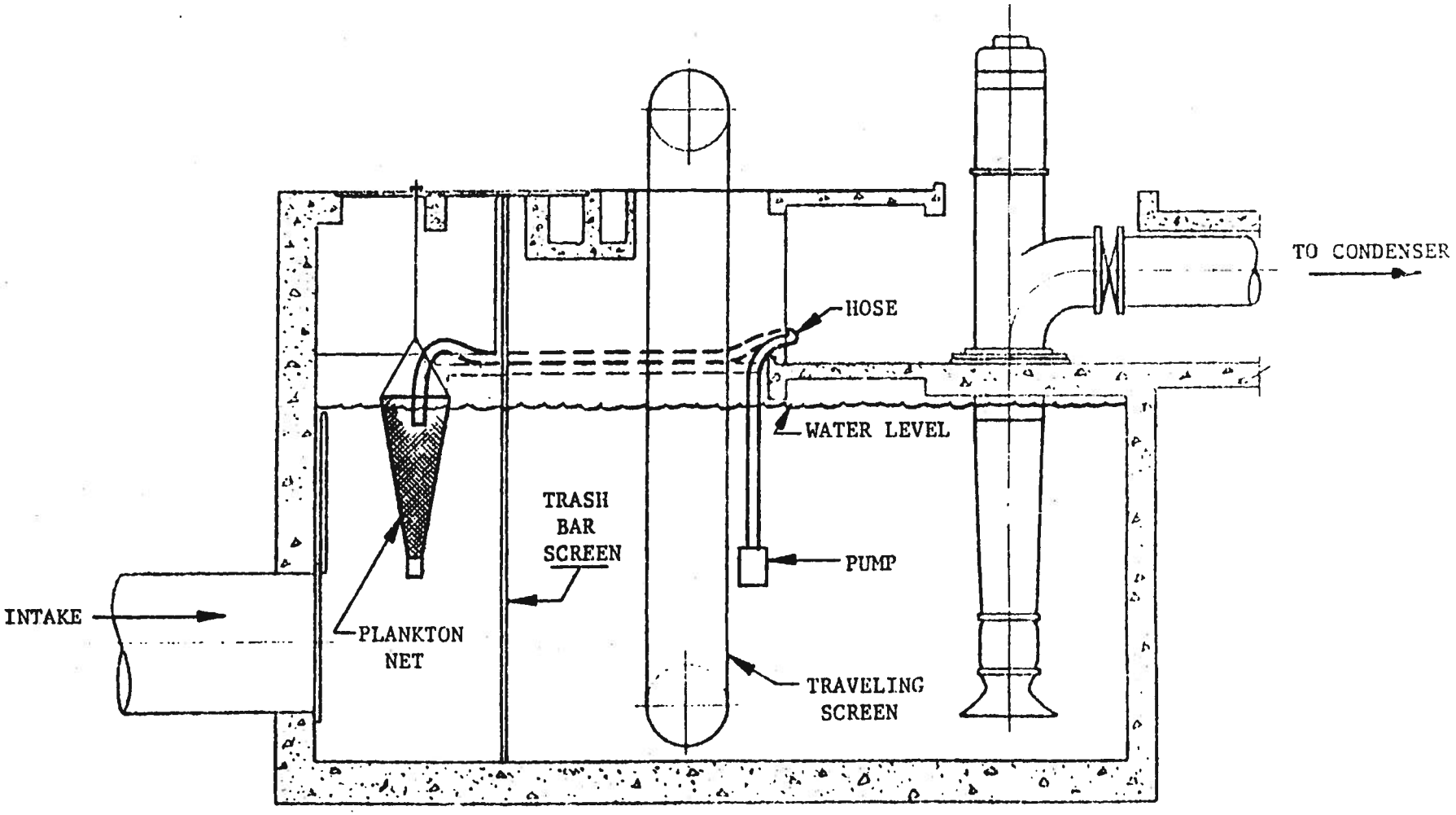

FIGURE 2-2

Samples for fish eggs and larvae in the Harbor waters (source water body) were not collected. This was based on low entrainment figures from plankton net sampling.

2.2.2 SAMPLING RESULTS

Samples collected from January 1 through May 10, 1976, contained no fish eggs or larvae. Eggs were found in the samples from May 17 through June 21, and also in the samples of July 5 and August 2. Larvae were found in the samples of July 5, 12 & 27, August 2 & 9, September 20 & 27, and October 4, 11 & 25. Samples collected from November 1 through December 31, 1976, contained no fish eggs or larvae.

A total of 200 eggs were found in eight samples. Smelt eggs accounted for 88.5% (177 eggs) while the remaining 23 eggs were unidentified. Egg counts were highest in the May 17th and 24th samples which contained 87 and 63 smelt eggs, respectively.

A total of 796 larvae were collected in ten samples. A breakdown of the larvae total shows: 782 smelt larvae, 2 burbot larvae, 1 perch larvae and 11 unidentified larvae. Most of the larvae were in the July 5th and 12th samples which had counts of 379 and 402 smelt larvae, respectively.

Table 2-7 is a summary of fish egg and larvae results for each sample collected during the one-year monitoring program. Table 2-7 also contains data on cooling water flow and an estimate of the total number of fish eggs and larvae entrained during the sample period.

TABLE 2-7

SUMMARY OF SAMPLES FOR FISH EGGS AND LARVAE ENTRAINED IN THE COOLING WATER INTAKE DURING ONE-YEAR MONITORING PROGRAM

DATE	SAMPLE VOLUME (GAL.x10^6)	TOTAL GALLONS THROUGH PLANT (x10^6)	% WATER SAMPLED	ORGANISMS		ORGANISMS PER 100 ℓ SAMPLED *	ESTIMATED TOTAL NUMBER OF ORGANISMS ENTRAINED DURING SAMPLE PERIOD
				NUMBER OF FISH EGGS	NUMBER OF FISH LARVAE		
JAN. 7	0.0264	141.0	0.019	0	0	0	0
15	0.0778	141.0	0.055	0	0	0	0
21	0.0955	141.0	0.068	0	0	0	0
27	0.0810	141.0	0.057	0	0	0	0
FEB. 2	0.0864	141.0	0.061	0	0	0	0
12	0.0864	141.0	0.061	0	0	0	0
16	0.0864	141.0	0.061	0	0	0	0
23	0.0864	141.0	0.061	0	0	0	0
MARCH 3	0.0864	141.0	0.061	0	0	0	0
8	0.0864	141.0	0.061	0	0	0	0
15	0.0864	141.0	0.061	0	0	0	0
22	0.0864	141.0	0.061	0	0	0	0
29	0.0864	141.0	0.061	0	0	0	0

* - NOT SUBMITTED ON QUARTERLY REPORTS IF LESS THAN 0.001

TABLE 2-7 (cont.)

DATE	SAMPLE VOLUME (GAL.x10^6)	TOTAL GALLONS THROUGH PLANT (x10^6)	% WATER SAMPLED	ORGANISMS		ORGANISMS PER 100 ℓ SAMPLED *	ESTIMATED TOTAL NUMBER OF ORGANISMS ENTRAINED DURING SAMPLE PERIOD
				NUMBER OF FISH EGGS	NUMBER OF FISH LARVAE		
APRIL 5	0.0864	141.0	0.061	0	0	0	0
12	0.0882	141.0	0.062	0	0	0	0
19	0.0864	141.0	0.061	0	0	0	0
26	0.0864	141.0	0.061	0	0	0	0
MAY 3	0.0864	141.0	0.061	0	0	0	0
10	0.0828	141.0	0.059	0	0	0	0
** 17	0.1249	187.0	0.067	87	0	0.0184	130,273
** 24	0.1605	187.0	0.086	63	0	0.0104	73,633
JUNE 1	0.0864	187.0	0.046	15	0	0.0046	32,568
7	0.0864	187.0	0.046	12	0	0.0037	26,1[illegible]
14	0.0864	187.0	0.046	8	0	0.0024	16,992
21	0.0756	154.7	0.049	5	0	0.0017	9,954
28	0.1224	141.0	0.087	0	0	0	0

* - NOT SUBMITTED ON QUARTERLY REPORTS IF LESS THAN 0.001

** - AVERAGE OF RESULTS FROM STRATIFICATION SAMPLING

TABLE 2-7 (cont.)

DATE	SAMPLE VOLUME (GAL.x10^6)	TOTAL GALLONS THROUGH PLANT (x10^6)	% WATER SAMPLED	ORGANISMS		ORGANISMS PER 100 ℓ SAMPLED *	ESTIMATED TOTAL NUMBER OF ORGANISMS ENTRAINED DURING SAMPLE PERIOD
				NUMBER OF FISH EGGS	NUMBER OF FISH LARVAE		
JULY 6	0.1224	141.0	0.087	5	379	0.0829	442,360
12	0.1224	141.0	0.087	0	402	0.0868	463,160
19	0.1224	141.0	0.087	0	0	0	0
27	0.1173	187.4	0.062	0	1	0.0002	1,419
AUG. 2	0.1173	187.0	0.063	5	1	0.0013	7,788
9	0.1224	187.0	0.065	0	1	0.0002	1,416
16	0.1224	187.0	0.065	0	0	0	0
23	0.1224	187.0	0.065	0	0	0	0
30	0.1224	187.0	0.065	0	0	0	0
SEPT. 6	0.1224	187.0	0.065	0	0	0	0
13	0.1224	187.0	0.065	0	0	0	0
20	0.1224	187.0	0.065	0	1	0.0002	1,416
27	0.1224	187.0	0.065	0	1	0.0002	1,416

* - NOT SUBMITTED ON QUARTERLY REPORTS IF LESS THAN 0.001

TABLE 2-7 (cont.)

DATE	SAMPLE VOLUME (GAL.x10^6)	TOTAL GALLONS THROUGH PLANT (x10^6)	% WATER SAMPLED	ORGANISMS NUMBER OF FISH EGGS	ORGANISMS NUMBER OF FISH LARVAE	ORGANISMS PER 100 ℓ SAMPLED *	ESTIMATED TOTAL NUMBER OF ORGANISMS ENTRAINED DURING SAMPLE PERIOD
OCT. 4	0.1325	187.0	0.071	0	8	0.0016	11,328
11	0.1325	187.0	0.071	0	1	0.0002	1,416
18	0.1325	187.0	0.071	0	0	0	0
25	0.1325	187.0	0.071	0	1	0.0002	1,416
NOV. 1	0.1325	187.0	0.071	0	0	0	0
8	0.1325	169.8	0.078	0	0	0	0
15	0.1325	141.0	0.094	0	0	0	0
22	0.1325	141.0	0.094	0	0	0	0
29	0.1325	187.0	0.071	0	0	0	0
DEC. 6	0.1325	141.0	0.094	0	0	0	0
13	0.1325	141.0	0.094	0	0	0	0
20	0.1325	141.0	0.094	0	0	0	0
27	0.1325	187.0	0.071	0	0	0	0

* - NOT SUBMITTED ON QUARTERLY REPORTS IF LESS THAN 0.001

SECTION 3

ANALYSIS OF INTAKE EFFECT

Sample results from the biological monitoring program provide the basis for assessing the impact of Taconite Harbor Power Plant cooling water usage on the fishery resources of Lake Superior. For purposes of analysis and discussion, results will be projected over annual plant operation to determine total effects.

3.1 ANALYSIS ADULT AND IMMATURE FISH IMPINGEMENT

Adult and immature fish impingement in the intake structure is best represented by combining the results of the traveling screen discharge catch basket and the removal of dead floating fish from the screen well. Twelve species of fish were encountered, but smelt comprised nearly the entire annual total. Burbot was the only other species with noticeable impingement figures (greater than 1% of the total).

3.1.1 ANNUAL IMPINGEMENT

Total annual impingement of adult and immature fish is calculated by adding the results of the traveling screen discharge catch basket (Table 2-1) and the results of removing dead floating fish from the screen well (Table 2-3). Table 3-1 lists total numbers of impinged fish by species for the year, and Table 3-2 contains monthly statistics. A review of Tables 3-1 and 3-2 shows the following: Smelt was the most frequently collected species, amounting to 9,993 individuals and comprising 98.24% of the total. May and June, the heaviest months of smelt impingement, directly followed the smelt spawn. During these two months, 9,505 smelt were collected which were 88.7% of

TABLE 3-1

ANNUAL SUMMARY OF ADULT & IMMATURE FISH IMPINGEMENT IN THE INTAKE STRUCTURE (TABLE 2-1 PLUS TABLE 2-3)

SPECIES	NUMBER	% TOTAL NUMBER
SMELT	9,993	98.24
BURBOT	115	1.13
CISCO	25	0.24
ALEWIFE	21	0.21
STICKLEBACK MINNOW	6	0.06
WALLEYE	3	0.03
NORTHERN PIKE	3	0.03
WHITEFISH	2	0.02
LAKE TROUT	1	0.01
BLUE FIN HERRING	1	0.01
BULLHEAD	1	0.01
LAMPREY	1	0.01
TOTAL NUMBER	10,172	

TABLE 3-2

MONTHLY SUMMARY OF ADULT AND IMMATURE FISH IMPINGEMENT
IN THE INTAKE STRUCTURE (TABLE 2-2 PLUS TABLE 2-4)

MONTH	SMELT	BURBOT	CISCO	ALEWIFE	STICKLEBACK MINNOW	WALLEYE
JANUARY	12	14				1
FEBRUARY	14					
MARCH	47					
APRIL	236	1			6	
MAY	2,441					
JUNE	7,064	5	20			
JULY	72	12	5	6		
AUGUST	25	26		4		1
SEPTEMBER	69	31		10		
OCTOBER	7	14				
NOVEMBER	3	5				1
DECEMBER	3	7		1		
TOTALS	9,993	115	25	21	6	3

TABLE 3-2 (cont.)

MONTH	NORTHERN PIKE	WHITEFISH	LAKE TROUT	BLUE FIN HERRING	BULLHEAD	LAMPREY
JANUARY	3					1
FEBRUARY						
MARCH						
APRIL						
MAY						
JUNE						
JULY		1				
AUGUST		1				
SEPTEMBER						
OCTOBER						
NOVEMBER					1	
DECEMBER			1	1		
TOTALS	3	2	1	1	1	1

the total annual impingement. Burbot impingement was 115 individuals with the majority collected during the last six months of 1976. Burbot represented 1.13% of the total annual impingement. Two other species, cisco and alewife, had respective impingement totals of 25 and 21 individuals comprising 0.24% and 0.21% of the total annual impingement. The other eight species accounted for the remaining 0.18% of the total annual impingement. Figures for these species are very low, and further discussion on them will provide no meaningful conclusions.

3.1.2 SMELT

As previously mentioned, smelt impingement accounted for 98.24% of the total annual impingement. Most of the smelt were impinged during May and June, directly following the smelt spawn. Many of these smelt were suffering from saprolegnia. An accurate count was not made of those individuals infected, but it surely exceeded two-thirds. Saprolegnia is a growth of fungus on the smelt body where there is a lack of protective slime.[1] Physical rigors of the smelt spawning run probably caused the loss of the protective slime. Individuals with saprolegnia are in a weakened condition which facilitates impingement. Therefore, the annual smelt impingement total is inflated by a number of unhealthy fish which were unable to resist the intake pipe water velocity as healthy smelt are capable of doing.

Netting results in Tables 2-5 and 2-6 provide little information as to smelt population in the proximity of the intake pipes and no basis for comparison with impingement totals. The mesh sizes of

the test gill net panels were not small enough for efficient smelt netting. However, there are figures describing the relative abundance of smelt in the Minnesota waters of Lake Superior. A Minnesota Department of Natural Resources study entitled "Lake Superior Commercial Fish Assessment Studies - Status of Lake Superior Fish Stocks - 1976" discusses relative abundances of smelt and other species. Figures are based on fish production in terms of CPE (catch per effort) with units of pounds of fish per 1,000 feet of net. Smelt production in 1976 amounted to 2.6 million pounds which is the highest commercial production of smelt in Minnesota waters.[2] Smelt impingement in the intake structure numbered 9,993 individuals, and can be converted to 1,250 pounds by assuming an average weight of two ounces per smelt. Total pounds of smelt impinged is extremely small when compared with commercial fishing catches from a stable smelt production, and the smelt loss from impingement will certainly have no effect on total smelt populations in the Minnesota waters of Lake Superior.

3.1.3 BURBOT

Burbot, the only species other than smelt with noticeable impingement figures, represented 1.13% (115 individuals) of the total annual impingement. Netting of burbot from waters in the proximity of the intake pipes produced five burbot during the two efforts (Tables 2-5 and 2-6). Comparisons of netting results to impingement results for May and June show that 100% of the netted burbot were also impinged.

However, total annual impingement of burbot is very low and will have no impact on the burbot population. The Minnesota Department of Natural Resources has no figures for the relative abundance of burbot, but Eddy and Underhill noted that the fish is fairly secure from extinction because it lives in deep water (400 foot depths) in the summer, and seldom bites except in shallow water during the winter. Burbot are also prolific spawners, producing as many as one million eggs per female.[3]

3.1.4 OTHER SPECIES

Cisco and alewife annual impingement totals were extremely low as they amounted to 25 and 21 individuals, respectively. Comparison with netting results is not possible as neither species was caught in the gill net. Relative abundance figures are available for ciscoes from the MDNR study mentioned in Section 3.1.2. CPE figures increased for cisco during 1976, and a total of 63,000 pounds were taken commercially.[4] Surely, the annual impingement of 25 individuals will have no effect on the cisco population in the Minnesota waters of Lake Superior in light of the 1976 commercial take. Estimates of alewife populations were not available. It appears that alewife populations may be too large in the Great Lakes as noted by Eddy and Underhill. There also is controversy over introducing other predacious species in the hope of controlling the alewives, and large summer kills of alewife have been noted in Lake Michigan.[5] Annual impingement of 21 alewives will have no effect on alewife population in light of these facts. The other eight species have such low impingement totals that no deleterious effect on fishery resources is possible.

3.2 ANALYSIS OF FISH EGG AND LARVAE ENTRAINMENT

Fish eggs and larvae were found in 16 of 52 weekly samples collected during the one-year monitoring program. Smelt eggs and larvae were most frequently encountered and comprised most of the total numbers. Identification of organisms was hampered by the damage done to some eggs and larvae as they passed through the sampling equipment. Figures based on weekly samples will be projected over yearly plant operation to estimate total annual fish egg and larvae entrainment.

3.2.1 ANNUAL ENTRAINMENT ESTIMATES

Table 2-7 contains an estimate of the total number of organisms entrained during the sample period. Annual entrainment can be estimated by assuming each plankton net sample result is representative of the entrainment occurring in the three days of plant operation preceding and the three days of plant operation following the sample day. Therefore, each 24-hour sample result in units of fish eggs and/or larvae per 100 liters will be multiplied by total plant flow for the seven consecutive days surrounding the sample day. Adding these figures for the 16 weeks with fish egg and/or larvae counts in the plankton net sample will give an estimate of the total number of fish eggs and larvae annually entrained in the cooling water. Table 3-3 shows the calculations for obtaining the weekly cooling water usage applicable for each plankton net sample. Table 3-4 contains the estimate of total annual entrainment of fish eggs and larvae in the cooling water. Estimates of annual entrainment are 2,125,794 fish eggs and 6,447,558 fish larvae, and each estimate will be discussed below.

TABLE 3-3

WEEKLY COOLING WATER USAGE FOR EACH PLANKTON NET SAMPLE

PLANKTON NET SAMPLE DATE	TOTAL COOLING WATER USAGE PER DAY, GAL. x 10^6							TOTAL COOLING WATER USAGE FOR WEEK	
	THREE DAYS PRECEEDING			SAMPLE DAY	THREE DAYS FOLLOWING				
	3rd DAY	2nd DAY	1st DAY		1st DAY	2nd DAY	3rd DAY	GAL. x 10^6	100# x 10^4
MAY 17	187.0	187.0	187.0	187.0	187.0	187.2	187.0	1,309.2	4,955
MAY 24	187.0	187.0	187.0	187.0	187.1	187.0	187.0	1,309.1	4,955
JUNE 1	187.0	187.0	187.0	187.0	187.1	187.0	187.0	1,309.1	4,955
JUNE 7	187.0	187.0	187.0	187.0	187.1	187.0	187.0	1,309.1	4,955
JUNE 14	187.0	187.0	187.0	187.0	187.0	187.1	187.0	1,309.1	4,955
JUNE 21	158.3	141.0	141.0	154.7	187.0	187.1	164.0	1,133.1	4,289
JULY 6	141.0	141.0	141.0	141.0	141.0	141.0	141.0	987.0	3,736
JULY 12	141.0	141.0	141.0	141.0	141.0	141.0	141.0	987.0	3,736
JULY 27	187.0	187.0	187.0	187.4	187.0	187.1	187.0	1,309.5	4,956
AUG. 2	187.0	187.0	187.0	187.0	187.0	187.8	187.7	1,310.5	4,960
AUG. 9	187.0	187.0	187.0	187.0	187.0	187.0	187.0	1,309.0	4,955
SEPT. 20	187.1	187.0	187.0	187.0	187.0	187.0	187.0	1,309.1	4,955
SEPT. 27	187.1	187.0	187.0	187.0	187.0	187.0	187.1	1,309.2	4,955
OCT. 4	187.0	187.0	187.0	187.0	187.0	187.0	187.0	1,309.0	4,955
OCT. 11	187.1	187.0	187.0	187.0	187.0	187.0	187.1	1,309.2	4,955
OCT. 25	187.1	187.0	187.0	187.0	187.0	187.0	187.1	1,309.2	4,955

TABLE 3-4

ESTIMATED TOTAL NUMBER OF FISH EGGS AND LARVAE ENTRAINED ANNUALLY

PLANKTON NET SAMPLE DATE		SAMPLE RESULTS					WEEKLY ENTRAINMENT ESTIMATES	
	SAMPLE VOLUME (100ℓ)	NUMBER OF FISH EGGS	NUMBER OF FISH LARVAE	FISH EGGS PER 100ℓ SAMPLED	FISH LARVAE PER 100ℓ SAMPLED	COOLING WATER USAGE FOR WEEK (100ℓ x 10^4)	NUMBER OF FISH EGGS	NUMBER OF FISH LARVAE
MAY 17	4,727	87	0	0.0184	0	4,955	911,720	0
MAY 24	6,075	63	0	0.0104	0	4,955	515,320	0
JUNE 1	3,270	15	0	0.0046	0	4,955	227,930	0
JUNE 7	3,270	12	0	0.0037	0	4,955	183,335	0
JUNE 14	3,270	8*	0	0.0024	0	4,955	118,920	0
JUNE 21	2,861	5*	0	0.0017	0	4,289	72,913	0
JULY 6	4,633	5*	379	0.0011	0.0818	3,736	41,096	3,056,048
JULY 12	4,633	0	402	0	0.0868	3,736	0	3,242,848
JULY 27	4,440	0	1	0	0.0002	4,956	0	9,912
AUG. 2	4,440	5*	1	0.0011	0.0002	4,960	54,560	9,920
AUG. 9	4,633	0	1*	0	0.0002	4,955	0	9,910
SEPT. 20	4,633	0	1	0	0.0002	4,955	0	9,910
SEPT. 27	4,633	0	1	0	0.0002	4,955	0	9,910
OCT. 4	5,015	0	8*	0	0.0016	4,955	0	79,280
OCT. 11	5,015	0	1*	0	0.0002	4,955	0	9,910
OCT. 25	5,015	0	1*	0	0.0002	4,955	0	9,910
			* - UNIDENTIFIED		ANNUAL TOTAL		2,125,794	6,447,558

p38 mostly smelt

See p. 40 for species composit

3.2.2 DISCUSSION OF ANNUAL FISH EGG ENTRAINMENT ESTIMATE

Fish eggs were found in 8 of the 52 plankton net samples and amounted to 200 eggs. Identification of the eggs was not always possible due to damage from passing through the sampling equipment. Only 23 eggs were in an unidentifiable condition, and the other 177 eggs were identified as smelt eggs. The 177 smelt eggs were in the samples of May 17th and 24th, and June 1st and 7th. On the basis of the annual total entrainment estimate for fish eggs from Table 3-4, cooling water usage during these weeks entrained 1,838,305 smelt eggs. This figure represents 86.5% of the total annual entrainment estimate.

Upon initial review, 1,838,305 smelt eggs may seem like a large total. However, smelt are random spawners and an average adult female contains 30,000 eggs.[6] Eddy and Underhill report that a very large proportion of smelt eggs are fertilized and large numbers hatch. Mortality of the fry (larvae) is very high, and success to adult stage is very low.[7] Actual mortality rates of smelt fry were not discovered in any literature that was researched. It can be assumed that smelt fry probably face similar survival statistics as those mentioned for sunfish and crappie fry in Northern Fishes by Eddy and Underhill. Studies of sunfish and crappies have shown that only a small number of fry, ranging up to 3 percent, survive to become fingerlings or one-year-old fish. From 10 to 75 percent of the fingerlings survive to become two-year-olds, and from 10 to 45 percent of the two-year-olds survive at the

end of the third year, at which time most of these fish reach what might be called adult size. The results of the studies clearly indicate that a large number of fry must be produced annually, since only a very small fraction will survive to become adults.[8] From this discussion, it is apparent that egg to fry to adult success is probably less than 0.1%. Entrainment of 1,838,305 smelt eggs probably represents less than 1,000 adult smelt, and the loss of 1,000 adult smelt is inconsequential as previously discussed in Section 3.1.2. Another pertinent view of the annual entrainment of 1,838,305 smelt eggs is that it represents the fecundity of 61 adult female smelt assuming that an average adult female contains 30,000 eggs. Certainly the loss of the spawning potential of 61 adult female smelt is extremely minute.

It is probable that smelt eggs found in the intake system were dead before entrainment. Smelt eggs are spawned with a sticky substance that attaches them to the rocks and bottom of shallow, moving waters such as the many streams and rivers entering Lake Superior. Adhering to the rocks is the only means for the eggs to absorb oxygen and hatch into fry. Once the bond with the rocks is broken, the eggs will die with no chance of hatching. Fish eggs floating in the water near the intake pipes and entrained in the intake system were probably already dead and represent no real loss.

The remainder of the estimated annual fish egg entrainment total consists of unidentified eggs. These 287,489 eggs probably face similar low odds of success to adult stage, and their loss will have no effect on the fishery resources of Lake Superior.

3.2.3 DISCUSSION OF ANNUAL FISH LARVAE ENTRAINMENT ESTIMATE

Fish larvae were found in 10 of the 52 plankton net samples and amounted to 796 larvae. Damage to larvae from the sampling equipment was less than for fish eggs. Of the 796 larvae, 782 were smelt, 2 were burbot, 1 was from the perch family and 11 were in an unidentifiable condition. The 782 smelt larvae were collected mainly in the samples of July 5th and 12th with one smelt larvae appearing in the September 27th sample. On the basis of the annual total entrainment estimate of fish larvae from Table 3-4, cooling water usage during these weeks entrained 6,308,806 smelt larvae. This figure represents 97.8% of the total annual entrainment estimate.

The effect of the annual entrainment of 6,308,806 smelt larvae can be judged using the same logic presented in Section 3.2.2. Success percentages for smelt fry (larvae) to reach the adult stage are very low. Therefore, the annual entrainment estimate probably represents a loss of less than 1,000 adult smelt. A loss of this size has already been described as inconsequential. The annual entrainment estimate also correlates to the fecundity of 210 adult females at 100% hatch. Loss of the spawning potential of 210 adult females will have no effect on Lake Superior smelt populations.

The smelt larvae collected in the three samples mentioned previously were all less than one centimeter in total length. Smelt fry should be considerably longer than one centimeter by July. Depending on water temperature, smelt eggs fertilized in late April hatch by late

May and are 1/2 centimeter in length at that time. Normal growth during June would definitely result in smelt with lengths exceeding 2 centimeters by mid-July.[9] Personnel of the Minnesota Department of Natural Resources reported seeing large numbers of floating dead smelt fry during the summer of 1976.[10] Rapid rise in lake temperature during that spring and summer was mentioned as the probable cause for this occurrence. Therefore, it is probable that most of these smaller than normal smelt fry entrained during July were already dead.

Annual burbot larvae entrainment was estimated at 19,832 larvae. The samples of July 27th and August 2nd each contained one burbot larvae and were the basis for the above estimate. Burbot are very prolific and one female can produce as many as 1,000,000 eggs.

The entrainment of 19,832 burbot larvae accounts for a small portion of the spawning potential of one female burbot, and will have no effect on burbot populations.

The remainder of the estimated annual fish larvae entrainment total consists of 99,010 unidentified larvae and 9,910 larvae belonging to the perch family. After consideration of the mortality rate of all fish larvae regardless of species, the loss of these larvae will have no effect on the fishery resources of Lake Superior.

3.2.4 COMMENTS ON ENTRAINMENT ESTIMATES

Weekly entrainment estimates in Table 3-4 based on the collection of a single larvae are probably not representative of the true conditions and can hardly be considered valid. There probably is sizeable error in these weekly estimates as the appearance of one fish larvae in a 24 hour sample has practically no meaning. However, the total annual entrainment estimates are large enough to absorb the error.

The 52 weekly entrainment estimates in Table 3-4 do not lend themselves readily to statistical analysis. There are large differences from one week to the next with many weeks of zero entrainment. Weekly estimates of fish egg entrainment vary from 0 to 911,720 and include 44 weeks of zero entrainment. Weekly estimates of larvae entrainment vary from 0 to 3,242,848 and include 42 weeks of zero entrainment. Results of the statistical analysis are listed below:

	WEEKLY ENTRAINMENT ESTIMATES	
	FISH EGGS	FISH LARVAE
Sample Size	52	52
Arithmetic Mean	40,881	124,000
Standard Deviation	±148,163	±611,378

SECTION 4

CONCLUSIONS

Cooling water usage at the Taconite Harbor Power Plant has been proven throughout this report to have no measurable impact on the fishery resources of the Minnesota waters of Lake Superior. The evidence developed also eliminates the need for any modification or future biological monitoring of the cooling water intake structure.

Annual impingement and entrainment losses, developed from the more than adequate sampling program, have been demonstrated to be miminal and confined to the smelt species. Smelt population in Lake Superior have never been estimated, but the Minnesota Department of Natural Resources reports that commercial fishing production of smelt in 1976 was the highest recorded, and relative abundance figures in units of CPE (catch per effort) were the highest observed. All major game fish species were not affected at all, and the minimal smelt loss will have no measurable impact on Lake Superior.